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CONSTRAINT-FACT OR FICTION? COMPARISON OF DIFFERENT METHODS OF CONSTRAINT WITH NO CONSTRAINT IN UPPER LIMB FUNCTION IN MODERATELY SPASTIC HEMIPLEGIC CEREBRAL PALSY CHILDREN

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ABSTRACT

Background: Children with hemiplegic Cerebral Palsy often fail to use the involved upper extremity and learn to perform most tasks exclusively with their non involved upper extremity. The aim of the present study is to probe the constraint component of the dichotomy by comparing the effects of most invasive, least invasive and no constraint in improving affected upper limb functions in hemiplegic cerebral palsy children.

Method: Subjects of 3-8 years are coming at Pt. D. D. U. I. P. H., Delhi University, New Delhi was included between August and December 2009. The selected subjects were assigned randomly into 3 groups i.e. (least invasive) m CIMT, (most invasive) CIMT, and no CIMT and it was initially assessed by using the Quality of Upper Extremity Skills Test (QUEST)to obtain baseline scores 1-3 days before start of therapy. Subjects were treated by m CIMT (LI) with gentle holding and CIMT (MI) with splint and no CIMT (NC) with no restrain for 2 days/week (1 hr/day) for a total of 8 days over 4 weeks.

Results: Baseline comparison of mean ranks was done before treatment which was found to be insignificant (p=.795) showing that there was no significant difference between the pre QUEST scores of the subjects in the three groups before treatment. Post treatment the mean ranks of all the three groups showed a statistically significant difference (p=.000) with mean rank for the mCIMT group to be the highest.

Conclusions: The findings of this study reveal that the mCIMT is more effective than CIMT in children with hemiplegic cerebral palsy as the method of restraint in mCIMT is well tolerated than CIMT by children and little frustration is there due to constraint on unaffected extremity. Moreover, this type of restraint is cost-effective and easy to use than any other method.

KEYWORDS: Spastic Hemiplegic, Cerebral Palsy, Constraint

INTRODUCTION

Cerebral palsy (CP), defined broadly as "a nonprogressive motor impairment syndrome caused by a problem in the developing brain," [1]affects at least 2 in 1000 children in the United States and >1 million children under the age of 21 in the industrialized world.[1,] Motor impairment that is greater on one side of the body than the other may be characterized

as asymmetric cerebral palsy and constitutes at least one third of cases. A number of physical rehabilitation approaches have been used with cerebral palsy; however, there are considerable questions in the literature as to their efficacy.

Children with hemiparesis or substantially greater deficit in 1 upper extremity than the other comprise a significantly large group of those with CP.[2] There is some question as to the efficacy of current physical therapy (PT) and occupational therapy (OT) treatment approaches to CP. [3, 4, 5.]

In 1995, however, it was suggested that a promising new therapy for adults with hemiparesis consequent to stroke, known as Constraint-Induced Movement (CI) therapy, 6-11 offered a potentially efficacious approach to the treatment of juvenile hemiparesis. This technique was derived from basic research with adults and infant monkey and its aims to improve the hand and arm use of children with hemiplegia. In the same year it was suggested that Constraint-Induced Movement therapy was potentially efficacious for children with cerebral palsy given the great plasticity of their central nervous systems.[12] The first experiment with a pediatric population was carried out with the upper extremity of children ages 8months to 8 years who had asymmetric cerebral palsy stemming from a variety of causes.[13, 14] The results were at least as good as in adult patients with neurological damage.

Constraint-Induced Movement Therapy (CIMT) might be especially well suited for use with cerebral palsy children because of the great capacity for plasticity in the developing nervous system.[15,16] Other mechanisms regarding changes over longer time are axonal regeneration and sprouting12. Similarly, development of the corticospinal tract subserving distal extremity control has been found to be dependent on motor activity during a key critical period in the developing kitten. [17] Thus promoting early use through constraint induced movement therapy can enhance the development of spared circuitry, optimizing developmental motor skill potential. Based on this there were reports of numerous studies done on effects of CIMT to improve upper limb function in children with cerebral palsy.[18, 19] The results suggest that CIMT may be useful in the treatment of upper extremity dysfunction in hemiplegic CP and 2 weeks of constraining the unaffected limb, coupled with practice of functional movements of the impaired limb, may be an effective method for restoring motor function after cerebral insult.

Recently, it has been suggested that **Modified Constraint Induced Movement Therapy (mCIMT)** i.e. least invasive, may be an effective way of treating young children with hemiplegic cerebral palsy.[20] Because the restraints are often worn for extended periods (from 6 to 24 hours per day), the type of restraint should be a consideration in adapting the intervention to children. The following different types of restraints were used during the restraint period in the pediatric studies: casts (most invasive),[21,22,23] resting splints,[24,25] slings,[26] mitts,[27] and gentle intermittent physical restraints.[20] The authors concluded that whereas active practice is the important variable in treatment efficacy, the type of restraint is related to the intensity of practice if the restraint is worn during all of waking hours.[28] Specifically restraints that allow some use of the non-involved extremity will result in less intensive practice because the non-involved arm can still be used to complete tasks.

It involves physical constraint of the uninvolved or less affected arm to increase the use of the more involved or affected arm. This type of therapy has been successful in children with hemiplegia (or asymmetric upper extremity motor difficulties). Constraint therapy is also sometimes referred to as constraint induced movement therapy (CIMT) and constraint induced therapy (CIT) in the literature. Constraint therapy has been paired with intensive behavioural training or with less intensive practice involving traditional occupational therapy approaches.

METHODOLOGY

The aim of this research is to see the effect of different methods of constraint and less invasive method of constraint in cerebral palsy children to improve the upper extremity function. Children who met inclusion criteria were recruited consecutively in the chronological order in which their parents contacted the project, on self-referral or referral by pediatrician. Written consent was obtained from each subject's caregiver before participating in the study. The selected subjects were assigned randomly into 3 groups i.e. (least invasive) mCIMT, (most invasive) CIMT, and no CIMT. Subjects of each group were initially assessed by using the general Occupational Therapy Cerebral Palsy assessment Performa and were evaluated using the Quality of Upper Extremity Skills Test to obtain baseline scores 1-3 days before start of therapy. Inclusion criteria were as follows: spastic hemiplegic cerebral palsy diagnosed by pediatrician; age 3-8years; Modified Ashworth Scale score 0-3; independent sitting balance; understand simple commands. Exclusion criteria were as follow: no seizures disorder; modified Ashworth Score greater than 3 at shoulder/elbow/wrist; recent orthopedic surgery/casting on involved upper extremity; botulinum toxin or phenol block therapy in upper extremity musculature during past 6 months; taking medicine to reduce spasticity; mental retardation.

Outcome Measure

Quality of Upper Extremity Skills Test (QUEST) (DeMatteo et al. 1993), which supplies information relating to movement and postural responses and an evaluation of the quality of upper limb function with four domains: dissociated movements, grasps, protective extension, and weight bearing. The test is validated for use with children aged 18 mo- 8 years. Inter observer reliability ranges from 0.90 to 0.96. It is validated against Peabody Developmental Scale. (Appendix- D)

Procedure

After pilot study subjects with cerebral palsy, diagnosed by Pediatrician, who fulfilled the inclusion criteria were selected for the study. Written consent was obtained from each subject's caregiver before participating in the study. The selected subjects were assigned randomly into 3 groups i.e. (least invasive) mCIMT, (most invasive) CIMT, and no CIMT. Subjects of each group were initially assessed by using the general Occupational Therapy Cerebral Palsy assessment Performa and were evaluated using the Quality of Upper Extremity Skills Test to obtain baseline scores 1-3 days before start of therapy.

Treatment Program

The subjects were treated individually, working with the therapist.

Group A- Least Invasive (LI): Baseline assessment of the subjects was done by using the "Quality of Upper Extremity Skill Test". Subjects were treated by mCIMT (LI) i.e. restraint with gentle holding for 2 days/week (1 hr/day) for a total of 8 days over 4 weeks. Subjects were asked to perform the activities (grouped into gross and fine motor functions) with affected hand while the therapist gently restraint the subject's unaffected hand by holding. Subjects were reassessed again after 4 weeks by "Quality of Upper Extremity Skill Test" for post-treatment score.

Group B- Most Invasive (MI): Baseline assessment of the subjects was done by using the "Quality of Upper Extremity Skill Test". Subjects were treated by CIMT (MI) i.e. restraint with splint for 2 days/week (1 hr/day) for a total of 8 days over 4 weeks. Subjects were asked to perform the activities (grouped into gross and fine motor functions) with the

affected hand while constraining his/her unaffected hand with Shoulder-Elbow-Wrist-Hand Splint. Reassessment was done after 4 weeks with "Quality of Upper Extremity Skill Test" for post-treatment score.

Group C- No Constraint (NC): Baseline assessment of the subjects was done by using the "Quality of Upper Extremity Skill Test". Subjects perform the same activities for the same duration but no restraint was given on the unaffected hand. Subjects were reassessed again after 4 weeks by "Quality of Upper Extremity Skill Test" for post-treatment score. Once data collection was over it was sent for statistical analyses.

Designing and Fabrication of Shoulder-Elbow-Wrist-Hand Restriction Splint (SEWHS)*

[*Orthosis may be called splints; the American Society of Hand Therapists (ASHT) (1992) validated the two terms may be used interchangeably.]

Splint was designed, measured, and fabricated by a qualified POE. It was custom made for each subject in CIMT group. POE visited the pediatric department of IPH on call every time, took measurement, fabricated the splint for every subject. Before starting the treatment while wearing the splint, each subject was made to wear the splint for 20 minutes to check for any sensitivity reactions. The splint construction procedure was as follows:

Polypropylene sheet, aluminium strip, ethaform, press button, Velcro, and harness are used for fabrication of the splint: -

The splint consists of six parts. The parts of the splint are cut in the shape of the upper extremity to promote best fit. The measurements of the parts of the splint varied from subject to subject depending on the arm size, etc. The details for construction of each part are as follows: -

Part A: Cock-Up Piece for Wrist and Hand Portion of SEWHS

Length: Extends from the tip of the middle finger up to the 2/3 of forearm.

Breadth: According to the breadth of the subjects forearm and hand.

Part B: Hind Arm Shell Piece of SEWHS

To hold the arm and its breadth is according to the subject's arm

Part C: Shoulder Shell Piece of SEWHS

To resist the movement of the shoulder and its breadth is according to subject's shoulder.

Part D: Bended Aluminium Strip of SEWHS

To hold cock-up, hind arm shell, and shoulder shell components together and to hold the elbow in extension. It is extended from cock up component to shoulder shell.

Part E: Shoulder Harness of SEWHS

It is fabricated from 2" soft strapping material. The strapping is initiated on the posterior border of splint and directed across the back and towards the opposite shoulder. It then passes across the chest to the anterior splint.

Part F: Velcro Strap Extension and Attachment of SEWHS

Velcros are attached with press buttons on cock up component over the phalanges, metacarpals, thumb, wrist and forearm. Another Velcro is attached over the hind arm shell, shoulder shell and harness. This Velcro attachment is given to constantly maintain the splint in arm. Then the whole splint is padded with ethaform.

Figure 1: Showing the Shoulder-Elbow-Wrist-Hand Splint

Figure 2: Showing the Cock-Up Piece for Wrist and Hand

Each subject was given a demonstration regarding wearing of the splint by the therapist and any doubt in relation to this was clarified by the therapist.

Figure 3: Subject Performing Warm up Session While Shaking Hands High

Figure 4: Showing the Subject Squashing the Doughball in the Pancake While Wearing Splint on the Unaffected Extremity

Figure 5: Showing the Subject Performing on Form Board with No Constraint on Any Extremity

Activity Program

Start with subject sat on chair with feet flat on the floor. The table was at height so that the subject's arms are supported. After this warm up session was started with shake their hand high, low to the side, behind, and in front for 5 minutes.

CIMT Activities

Table 1: CIMT Activities

Activity Categories	Techniques	Targeted Movement	Time
Warm-up session	Subjects were asked to shake their hands high, low to the side, behind, and in front	Arm, forearm flexion, extension, abduction, wrist movement and fist opening and closing.	5 Minutes
Play with Dough	When subject was unable to open out their hand, the therapist facilitate hand opening and place the play dough into the subject's hand. Ball of dough: roll the ball on the table and then squash it into a flat pancake	Finger extension, fist opening, strengthen the small muscles of hand, squeezing, squishing, pushing, pulling, and molding, roll it into a "snake" to form letters, shapes or a spiral bowl	5 Minutes
Finger Games	Finger puppets were placed on fingers of the affected hand and the subject was encouraged to tell a story with the therapist by using the finger puppets.	The therapist creates a puppet show. This is similar to improvised storytelling. Finger individuation.	10 Minutes
Posting Box	Posting box was used and 10 coins of different sizes were posted using the affected hand.	In hand-manipulation.	10 Minutes
Jigsaw	Form boards were used and the subjects were asked to place all the pieces back into it.	Release accuracy	10 Minutes
Threading	Different sizes of beads and buttons were used, depending on the child's age and ability. The bead was held by the therapist with the subject threading with their affected hand. Minimum ten beads were set as a target to be threaded using the affected hand.	Precision grasp, maintaining grasp through changes in spatial orietntation.	15 Minutes

Data Analysis

This study used a 3 group experimental design that observed participants under 3 different conditions. Statistical difference was tested with the nonparametric Wilcoxon -Signed Rank test to determine any significant difference in QUEST scores among the total samples followed by Mann -Whitney test to determine any significant difference between

any two groups & Kruskal-wallis test to determine any significant difference among the three groups. The Level of significance taken was < 0.05. Data were analyzed with SPSS for windows (version 15).

RESULTS

Table 2: Distribution of Subject and Their Mean Age in Different Groups

	CIMT		m CIMT		No CIMT	
	Male	Female	Male	Female	Male	Female
Number	5	3	4	4	4	4
Mean age	5.4	6.3	5.6	5.8	6.2	5.8

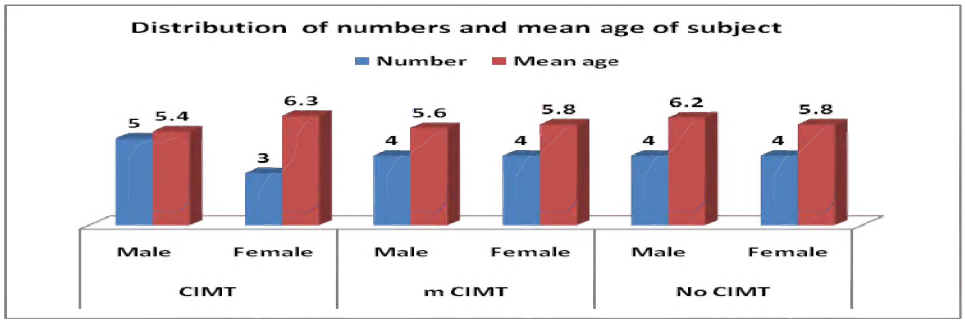

Figure 1: Showing the Distribution of Subjects in CIMT, m CIMT and No CIMT Group

Table 3: Comparison of Means and Standard Deviation of Three Groups

Groups	Pr Q		Po Q		Wilcoxon (PoQ-PrQ)
	Mean	S.D	Mean	S.D	
M CIMT	62.48	5.77	85.71	5.50	.012
CIMT	62.52	5.14	81.59	5.58	.012
No CIMT	61.16	2.69	67.42	4.91	.012

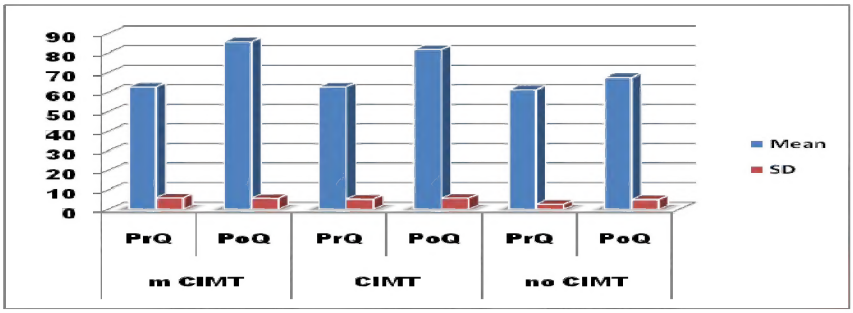

Figure 2: Showing Mean and Standard Deviation of the Three Group

Shows the mean and standard deviation, and significance values from the Wilcoxon signed rank test. Comparison of means of all three groups give p=.012, with a significance of 0.05

Table 4: Comparison between All Three Groups Using Mann-Whitney Test

	Group A		Group B		Group C	
Group	no CIMT	m CIMT	no CIMT	CIMT	CIMT	m CIMT
Mean Rank	4.50	12.50	4.50	12.50	6.50	10.50
Sum of Ranks	36.00	100.00	36.00	100.00	52.00	84.00
Exact. Sig. [2* (1-tailed Sig.)]	.000		.000		.105	

Between no CIMT and mCIMT and significance value (p=.000), between no CIMT and CIMT significance value (p=.000), between CIMT and mCIMT significance value (p=.105), which means there is significant difference between [noCIMT –m CIMT] and [no CIMT-CIMT] and no significant difference between CIMT-mCIMT groups.

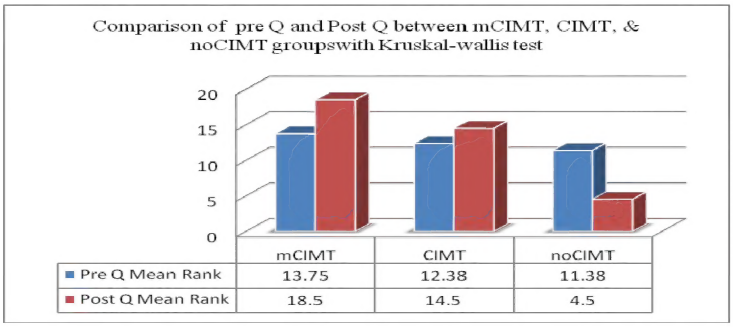

Figure 3: Showing the Mean Rank of the Three Groups before and after Treatment

Graph 3, shows the baseline comparison of mean ranks between no CIMT, CIMT, and mCIMT before treatment and significance value (p=.795) from Kruskal- Wallis test. This means that there is no significant difference between all three groups before treatment. But after treatment significance value (p=.000) from Kruskal-Wallis test showing that there is significant difference between all three groups but as mean rank is higher for mCIMT group that means it is most effective among all three groups.

DISCUSSIONS

This study concentrated on the comparison between effect of constraints graded from least invasive (mCIMT) to most invasive (CIMT) and no constraint on the upper extremity functions of children with hemiplegic cerebral palsy having mild to moderate spasticity and the findings indicated that subjects treated with mCIMT–i.e. least invasive constraint, showed most improvement in upper extremity functions, thereby supporting the research hypothesis.

In the present study, the sample size was small so the comparison of mean ranks of all the three groups was used to identify the most effective group. Graph 3 mCIMT is the most effective of all the three groups. Results of mCIMT group are in accordance with the findings of Naylor and Bower (2005), who also found significant improvement in hand function of nine children presenting with congenital spastic hemiplegia.[20]

As in the previous studies done on functional recovery after CIMT, the following imaging techniques were used: focal transcranial magnetic stimulation (Liepert et al, 2000),[29] positron emission tomography (Johansson et al, 2003)[30] or longitudinal voxel-based morphometry (Gauthier et al 2008)[31] and their result stated that not only does CI therapy produce functional changes involving increases in the differential excitability, metabolic activity, and oxygen consumption of sensorimotor regions of the brain but also it induces correlated morphometric changes by showing profuse gray matter increase in sensory and motor areas of brain and hippocampus. The hippocampus is known to be involved in learning and memory and these two processes may be associated with the improved limb use that occurs with the constraint induced movement therapy. We assume that in this study any one of the above findings could be the reason for the improvement in mCIMT group as none of the above kind of morphometric measurements or imaging techniques to record cortical reorganization secondary to mCIMT were used in this dissertation due to the methodological impossibility but the findings of this study can be attributed to the principles underlying brain plasticity to recruit areas of the brain to perform functions which have been lost due to focal injury.

For CIMT group (most invasive), statistically significant difference was found (p=.012) with mean rank of 14.50 after treatment. The results of this study are in accordance with the results of previous studies done on CIMT in children with hemiplegic cerebral palsy as Eliasson et al, 2005, done a study to evaluate the effects of CI therapy on bimanual hand use in children with hemiplegic cerebral palsy and the results suggested that the subjects in the experimental group improved their ability to use their hemiplegic hand significantly after treatment.[32] The results of this study may be attributed to the findings of the studies that have been performed in-utero and shortly after birth that suggest that CI therapy may be effective in children with hemiplegia.[33] As the mean rank for CIMT group (i.e. 14.50) is lower than the mean rank of mCIMT group (i.e. 18.50), this could be due to developmentally intrusive nature of the constraint, poor compliance to splint and increased level of frustration as attributed to the findings of a critical review done by Brian et al in 2009,[34] which stated that the studies reported drop-out while using a variety of restraints including a mitt, a splint, and a short arm cast and the reasons reported included general irritation and withdrawal from activities when the restraint was worn.[34]

In this study, the mean rank for no constraint was found to be the lowest (4.50) after treatment. We considered this group as experimental because each trial and each attempt to stand or walk will require bilateral activity in the legs and in performing upper limb activities the patient will use the non-affected side.[35] In previous studies, Actual Amount of Use Test (AAUT) was used as an implicit measure of actual and spontaneous use of affected arm.[36] Present study has objective of probing the effectiveness of least invasive to most invasive constraint by QUEST, consequently AAUT score was not documented to record the learned non-use(LNU). The findings of this group are consistent with the findings of the previous study done by Stephen J Page et al in 2008 in which the results showed that the subjects in the experimental group of mCIMT (p=.001) showed more improvement as compared to the no-treatment group.[37]

This study was done as an effort to answer a number of key questions regarding the dosage of restraint in both the factors i.e. the invasion and duration in children with hemiplegic cerebral palsy. The findings of this study suggest that clinically in occupational therapy practice where the activity remains unchanged the therapist should prefer least invasive constraint method which is developmentally appropriate for the pediatric population along with being cost-effective. Additionally advantageous is its inherent independence of requirements of any technical knowledge, practice, teaching, training by just single demonstration this method of constraint can easily be used for home program, school program and community program.

CONCLUSIONS

The findings of this study reveal that the mCIMT is more effective than CIMT in children with hemiplegic cerebral palsy as the method of restraint in mCIMT is well tolerated than CIMT by children and little frustration is there due to constraint on unaffected extremity. Moreover, this type of restraint is cost-effective and easy to use than any other method.

Limitation and Recommendation for Future Research

- Research involving CIMT or mCIMT should have longitudinal design or time-series design
- The result of this study has limited generalizability due to small sample size in each group.
- Standardization of the shaping activity protocol should be emphasized to be used with mCIMT or CIMT

- Home-based therapy protocol using mCIMT, CIMT and activity should be developed.
- Subjects were selected from only one institution hence the result can't be extrapolated.
- Further research involving neonates to 3 year should be given prime importance and ways of implementing constraint to this population should be searched.
- Efforts should be made to relate the aspects of constraints: invasion and duration should be considered for future research i.e. the method of restraint and the intensity of therapy should be matched.

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Competing Interests

All the authors have seen the final manuscript and approve it for submission. The authors have no competing interests in the publication of this manuscript to declare.

Author's Contributions

KPK conceived, designed apart from collecting data of the entire trial. She also analyzed and prepared the first draft of the manuscript. TA and VK were also instrumental in conceiving the study. VS was involved in study planning, data analysis and interpretation. All authors read and approved the final manuscript.

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